THE CONTENTS OF THIS SECTION ARE
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INITIAL _mmo_ DATE 7/30/01

Appendix E

Engineering Design File for the ARA-16 Pipe and Tank Removal Structural Analysis

Engineering Design File

PROJECT FILE NO. 020991

ARA-16 Pipe and Tank Removal with Structural Analysis

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

INEEL

Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

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Rev. 06

ENGINEERING DESIGN FILE

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3. Subtask _____

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4. Title: ARA-16 Pipe and Tank Removal With Structural Analysis

5. Summary: This EDF is to document the method to dismantle the ARA-16 piping, excavate the ARA-16 tank and lift it onto a transport truck for shipment to Allied Technology Group (ATG) in Washington. A structural analysis of the proposed lifting method is included. This action is part of the ARA-16 remedial action of Operable Unit 5-12: Power Burst Facility and Auxiliary Reactor Area and is in accordance with the signed Record of Decision.

Background Information

Site Description. Auxiliary Reactor Area (ARA)-16 is the site of a 1000-gal stainless-steel underground storage tank (ARA-729) located behind ARA-I. The tank was built in 1959 and taken out of service in 1988 when ARA-I was shut down. The tank was pumped out with approximately 6-in to 9-in of material remaining. All pipes and connections to the tank were removed and capped. The tank is located in a secondary containment consisting of an 8-in.-thick open concrete containment vault. Within the vault, the tank is nested in gravel. About 3.5 feet of mixed soil and gravel cover the tank and vault. The tank area is 30 x 30 ft and is surrounded by a barbed wire chain-link fence that is 7 ft tall and gated. Waste was transferred to the tank via 4-in and 2-in stainless steel pipes.

Tank Piping. The ARA-16 drain system has a total of 375 feet of 4-in stainless steel pipe and 127 feet of 2-in stainless steel pipe currently in the ground. The pipe inside Building 627 was removed by a previous D&D action. The pipe inside Building 626 was left in place. All drains in Building 626 have a lead drain plug installed (see attached drawing C-5). The tank-end of the pipe was permanently capped in 1988 however, the method of capping is unknown (ie. flange, valve, cap, etc...). In addition, it is unknown if the building-end of the pipes were ever open since this time; therefore, the current contents of the pipe are unknown. As a worst case scenario, the entire pipe could be filled adding 266 gallons of liquid to the total waste volume.

Tank Contents. ARA-16 was the recipient of liquid radioactive wastes from two processes, the hot cells operations in building ARA-626 and materials research and testing in ARA-627. Wash water was routed to the tank from the hot cells from 1959 until the facility was shut down in 1988. Materials research and testing were supported at ARA-I from 1970 to 1984, resulting in the disposal of radioactive metal etching fluids to ARA-16. As stated in the Power Burst Facility and Auxiliary Reactor Area Record of Decision, there is 4.5 gallons of sludge plus 312 gallons of liquid in the tank for a total volume of 316.5 gallons. The analytical results indicate an F-listed, TSCA regulated waste containing a variety of radionuclides, solvents, metals and organic compounds.

Transportation Plan

The method for transportation is to leave the contents inside the tank and secure it onto a truck to be shipped directly to ATG, Washington. By shipping the tank and pipes with the waste intact, worker exposure from decontamination actions are avoided. This method has been evaluated by Gene Kanemoto and his conclusions are discussed in a separate EDF (P&T-EDF-059).

Pipe Removal

Before any demolition takes place, the pipe will be reconnected to the tank to collect any waste that may be in the pipe. This can be accomplished by installing a self-tapping valve into the lowest point of the capped pipe. Insert the end of a hose into the 4-in inlet and attach the other end to the tapped valve. As a worst case scenario, the maximum possible volume of 266 gallons could empty into the tank without filling it. Once the pipe is empty, install a stainless steel section to reconnect the drain system to the tank.

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Begin excavating the pipe at the up-grade end and stockpile the soil as potentially contaminated with Cs-137. Cut each pipe into sections taking precaution to not allow any particles to escape from the pipe and place into an approved shipping container.

Tank Removal

The structural integrity of the tank is important to lifting the tank because there is no manufacture-installed lifting device designed to lift the tank with its contents. The two proposed lifting methods, described below, are basket slings under both ends of the tank and a fabricated flange for the 6-in and 18-in openings. These two methods have been evaluated by a structural engineer and the calculations are attached. Results of the finite element model show that either method of lifting the tank would not cause strains or stresses of sufficient magnitude to rupture the tank. Lifting devices, slings or lifting loops, are not addressed in this EDF. Either option shall be under strict accordance with the DOE Hoisting and Rigging Standard, DOE-STD-1090-99.

The first step in either option is to excavate the dirt from the top of the tank and containment vault and free the 4-in inlet pipe from the concrete vault. A vacuum excavation truck can be used to remove as much pit run gravel as possible from around the tank. The 4-in inlet pipe can be cut inside or outside the vault. Cutting inside the vault should be done after expanding sealant foam is used to fill the remaining inlet pipe. The sealant foam will prevent any spilling during lifting and transportation. Cutting outside the vault requires making a clean cut and applying a pressure plug to the pipe. The concrete must then be chipped away to provide unobstructed lifting of the pipe. The decision to cut inside or outside the vault will be made in the field after visual inspection.

Lifting Option 1 - Basket slings under the tank. Slings around both ends of the tank can be used to lift the tank. A distance no less than one foot from the ends of the tank must be accessible to provide adequate room for slings. An articulated attachment to the end of the vacuum excavation truck can be fabricated to remove the gravel from under the ends of the tank (see attached drawing). Once the ends of the tank are accessible, two workers can lower a basket sling between the ends of the tank and the containment vault and move the sling under the tank ends. The slings would then be attached to a spreader bar. The attached structural analysis modeled this option with the straps 6-in from the ends and in the worst case scenario, a full tank, there was no plastic deformation of the tank.
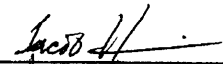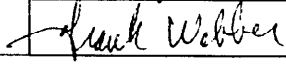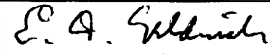
Lifting Option 2 - Utilize 6in and 18in flanges. If the ends of the tank cannot be made accessible to slings, flanges designed with lifting loops can be fabricated to fit the existing 6in and 18in openings. The existing blind flanges will be removed and replaced with the fabricated flanges. Slings and a spreader bar would attach to the lifting loop on each flange. The attached structural analysis modeled this option and in the worst case scenario, a full tank, there were no strains sufficient to rupture the tank.

Once the tank has been lifted and placed on the truck, unbolt the 4-inch inlet flange and replace with a blind flange to seal the inlet pipe for shipment. Load securing requirements are not addressed in this EDF.

6. Distribution (complete package):

   Distribution (summary package only):

7. Review (R) and Approval (A) Signatures: (Minimum reviews and approvals are listed. Additional reviews/approvals may be added as necessary.)

	R/A	Printed Name	Signature	Date
Author		Jacob Harris	*Jacob H*	24 May 2000
WAG 5 Project Manager	A	Frank Webber	*Frank Webber*	24 May 2000

ENGINEERING DESIGN FILE

1. Project File No. 020991		2. Project/Task Waste Area Group 5 Remedial Design/Remedial Action-Phase 1		
Technical Coordinator	R	Kurt Fritz		5/30/00
Project Engineer	R	Steve Davies		5/30/00

Calculation Cover Sheet

Project: Waste area Group 5 Remedial Design/Remedial Action - Phase 1	Calculation Number: Attachment to EDF-1406

Calculation Title: Stress Analysis for Lifting ARA-16 1000 Gal. Underground Tank

Summary of Calculation Purpose and Objective:

A tank containing an undetermined volume of fluid in the ARA-16 area needs to be lifted out of an underground concrete box. This analysis addresses the calculated stresses in the tank that result from lifting the tank by two nozzle flanges and also by lifting the tank with a sling under each end.

Quality Level (MCP-540 Definitions): ☐ 1 ☐ 2 ☒ 3 ☐ Other (Project Defined)

Level of Checking: ☐ Random Check
(Mark all that apply) ☒ Detailed Document Review
☐ Independent Calculations

Performance Category (DOE-STD-1020-94): ☐ PC-4 ☐ PC-3 ☐ PC-2 ☐ PC-1 ☒ PC-0 ☐ N/A

Independent Peer Review Required (required by DOE-STD-1020 for PC-2 or higher)? ☐ Yes ☒ No

Summary of Conclusions and Recommendations:

Results of these analyses show that the tank would be safe to lift by the nozzle flanges. Localized plastic deformation occurs in the tank wall where the stresses reach the yield strength of the material, but the plastic strains are small (less than 1%) compared to a rupture strain of about 40%.

Lifting the tank by straps under each end will result in maximum stresses of less than 8 ksi.

Either method of lifting the tank would not cause strains or stresses of sufficient magnitude to rupture the tank.

Revision Information and Signatures/Approvals(sign and date below typed or printed names)

Checker - Note pages checked next to signature. The checker's signature signifies that the pages noted have been checked at the level indicated above and using the methods indicated above. Thus, the checker's initials or signature is not required to appear on every page checked.

Rev. No.	Date	Description	Affected Pages
0	Apr. 17, 00	Initial issue	All

Originator Signature	Checker Signature	Group Lead/Supervisor Approval
B. D. Hawkes	*E. A. Goldmich* *pp.1-3, A-1, C-1-4, D-1&2*	*H. K. Miller* 4-17-00

Project: Waste Area Group 5 Remedial Design/Remedial Action - Phase 1   **Calc. No.:** EDF-1406 Attachment   **Rev.:** 0

Calc. Title: Stress Analysis for Lifting ARA-16 1000 Gal. Underground Tank

Originator: B. D. Hawkes   **Date:** 04/17/00   **Checked By:** E. D. Uldrich   **Date:** 04/17/00

Purpose

A tank containing an undetermined volume of fluid (liquid and sludge) in the ARA-16 area needs to be lifted out of an underground concrete box. This analysis addresses the calculated stresses in the tank that result from lifting the tank by two nozzle flanges and also by lifting the tank with a sling under each end.

Scope

This stress analysis applies only to the tank. Neither the lifting devices nor the lugs on the flanges are addressed in this report.

Quality Level

This is a quality level 3 project.

Natural Phenomena Hazards (NPH) Performance Category (PC)

This task has been assigned a performance category of zero.

Structure, System, or Component (SSC) Description

This tank is 4 feet in diameter and 12 feet long, fabricated from type 304L stainless steel. It was installed in 1959 and is buried under about 5 feet of soil in a concrete containment box that rests on basalt. The space between the tank and the containment box is filled with pit run gravel (See attached drawing in Appendix B). The top of this tank has several penetrations including an 18-inch diameter manhole and a 6-inch nozzle both capped with blind flange (see Fig. 1).

This tank contains an estimated 316.5 gallons of liquid, but the actual volume of liquid contained in this tank at the time of the lift is unknown. The actual wall thickness of this tank is unknown but is estimated to be either 0.086 in., 0.104 in. (12 gauge), or 0.134 in. (10 gauge).

Recent pictures taken of the inside of the tank show no apparent corrosion above the fluid level. The condition of the welds in the tank is unknown.

Project: Waste Area Group 5 Remedial Design/Remedial Action - Phase 1   **Calc. No.:** EDF-1406 Attachment   **Rev.:** 0

Calc. Title: Stress Analysis for Lifting ARA-16 1000 Gal. Underground Tank

Originator: B. D. Hawkes   **Date:** 04/17/00   **Checked By:** E. D. Uldrich   **Date:** 04/17/00
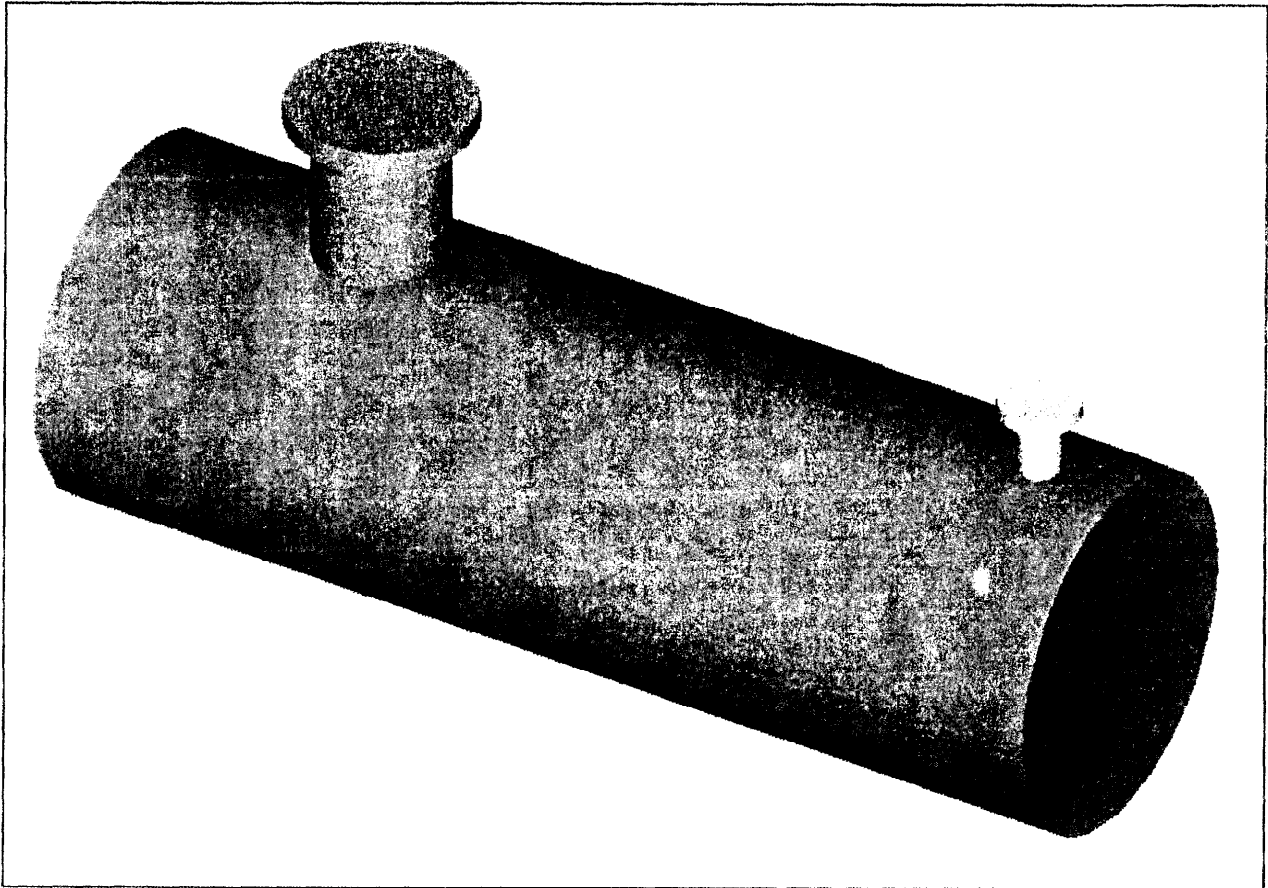
Figure 1 - Solid model of the tank and nozzles.

Materials

This tank is fabricated from type 304L stainless steel with a minimum specified yield strength of 25 ksi and a minimum specified tensile strength of 70 ksi (Ref. 1). The minimum elongation (strain at rupture) for this material is 40%, indicating that small plastic strains will not approach the tensile strength of the material (Ref. 2).

Loads

The fluid in the tank is assumed to have the specific gravity of seawater (64 lbf/ft^3). The stresses in the tank were evaluated with the tank full, 75% full, 50% full and 33% full. The current estimated volume of 316.5 gallons is less than 33% full.

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Originator: B. D. Hawkes   **Date:** 04/17/00   **Checked By:** E. D. Uldrich   **Date:** 04/17/00

Assumptions

It is assumed that:

1. The tank material is actually type 304L stainless steel.

2. The tank walls have not corroded to a thickness less than the evaluated thickness.

3. The welds in the tank are sound and have at least as much strength as the adjacent material.

4. The lifting loads on the nozzles will be vertical only. No horizontal forces will be exerted on the nozzles.

5. The tank is held level so the liquid in the tank will not accumulate in one end.

6. Sloshing and other forces from the movement of the fluid in the tank are not included in this analysis.
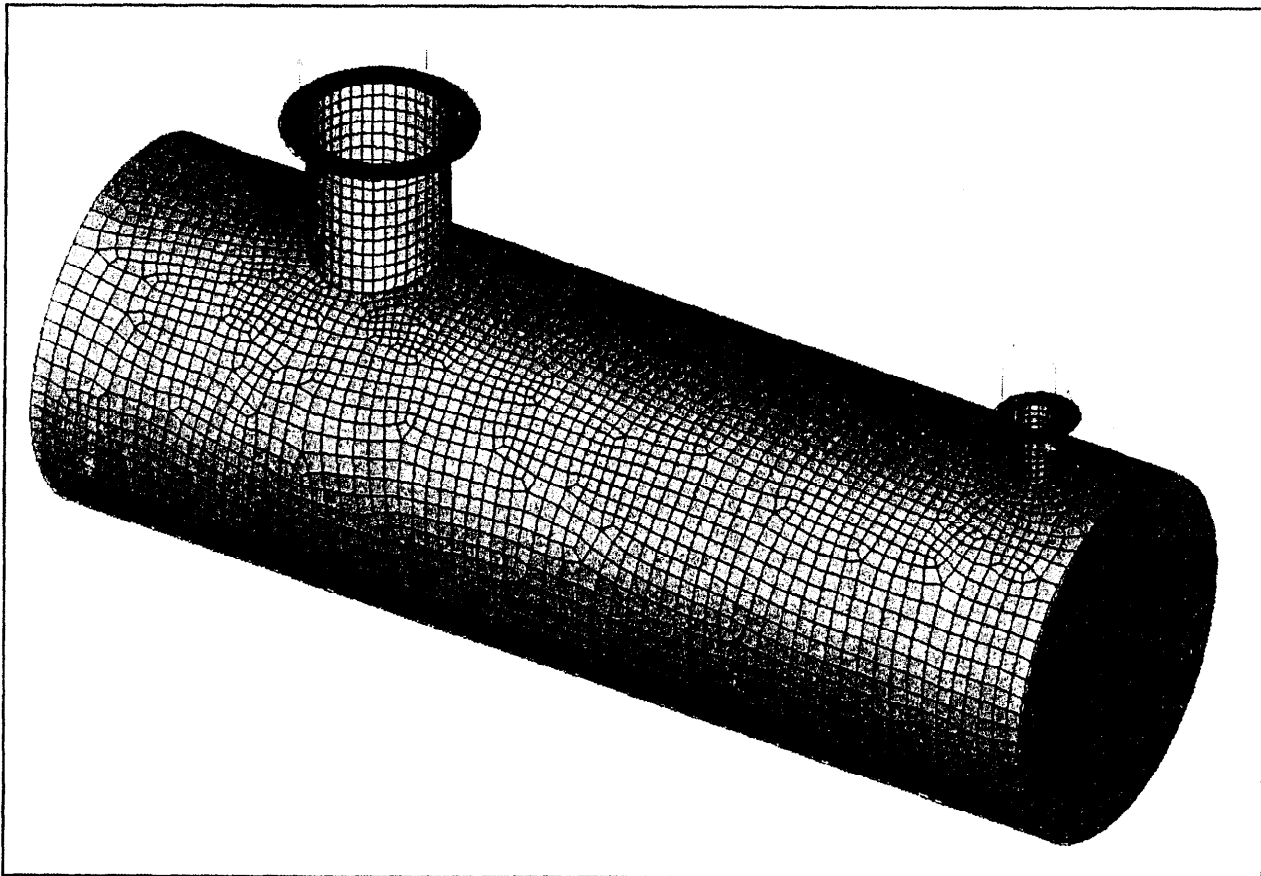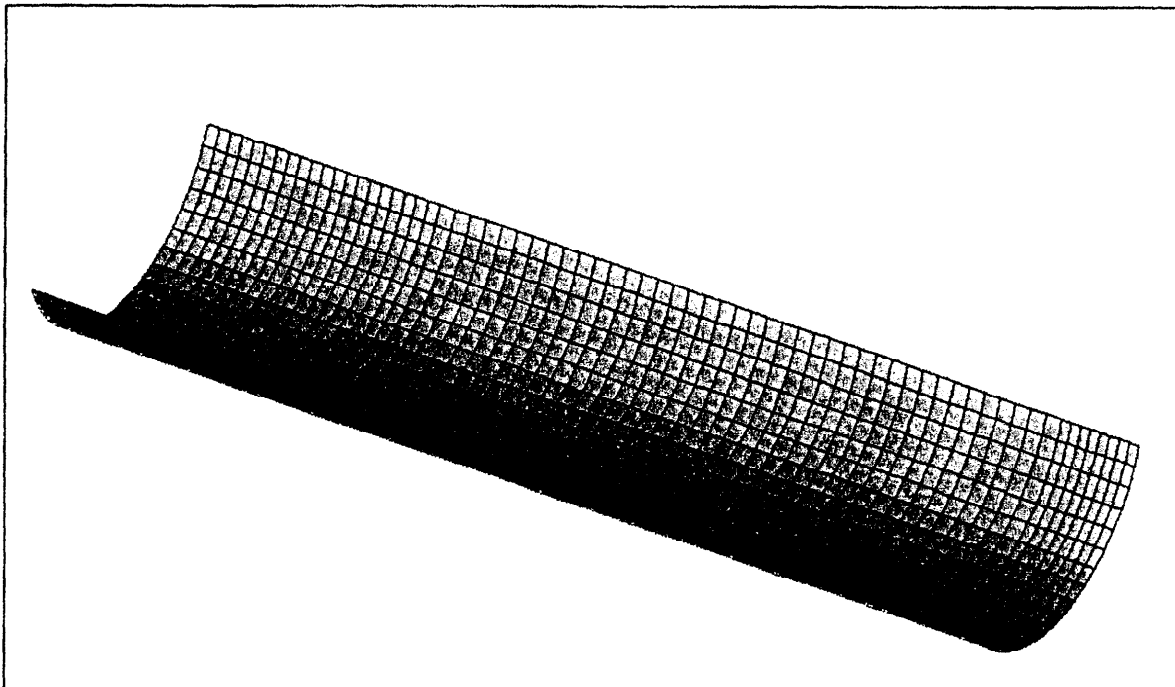

Figure 2 - Finite element model of the tank and nozzles.

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Acceptance Criteria

The tank wall must not rupture during the lift. This tank will not be used again, therefore, localized plastic deformation of the tank wall will be judged to be acceptable. This local plastic deformation of the tank is allowable since this will redistribute the stresses to the adjacent material. Small plastic strains in 304L are allowable since the minimum elongation at rupture is 40% (Ref. 1).

Figure 3 - The density of these elements at the bottom of the tank was increased to account for the weight of the fluid in the tank.

Calculations

A solid model and a finite element model of this tank (see Figures 1 and 2) were created using I-DEAS (Ref. 3). The finite element model was translated to an ABAQUS/Standard input file (See Appendix D). The flanges of the nozzles were restrained from movement in any direction (see Fig. 2). The density of the elements along the bottom of the tank was increased to account for the weight of the fluid in the tank (see Appendix C and Fig. 3). Hydrostatic stresses from the fluid in the tank were not taken into account. It was assumed that the pipe sections of the nozzles had the same wall thickness as the tank. The flanges were modeled as 150 pound weld neck flanges.

Results from the ABAQUS/Standard analysis show that the tank model, with a wall thickness of 0.086 inches and full of fluid, exhibited local areas of plastic deformation and small plastic strains (see Figure 4). Stresses in these areas reached the yield strength of the material and were redistributed to the surrounding

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material as the tank wall deformed plastically. True plastic strains in these areas were very small and did not exceed 1% at any location in the model (see Figure. 5).

A modification was made to the ABAQUS model to simulate the tank supported by slings under each end as shown in Figure 6. Von Mises stresses in the tank model with the 0.086 inch thick wall and full of fluid is shown in Figure 7. The maximum Von Mises stresses are about 7,420 psi and occur in the regions of the slings.
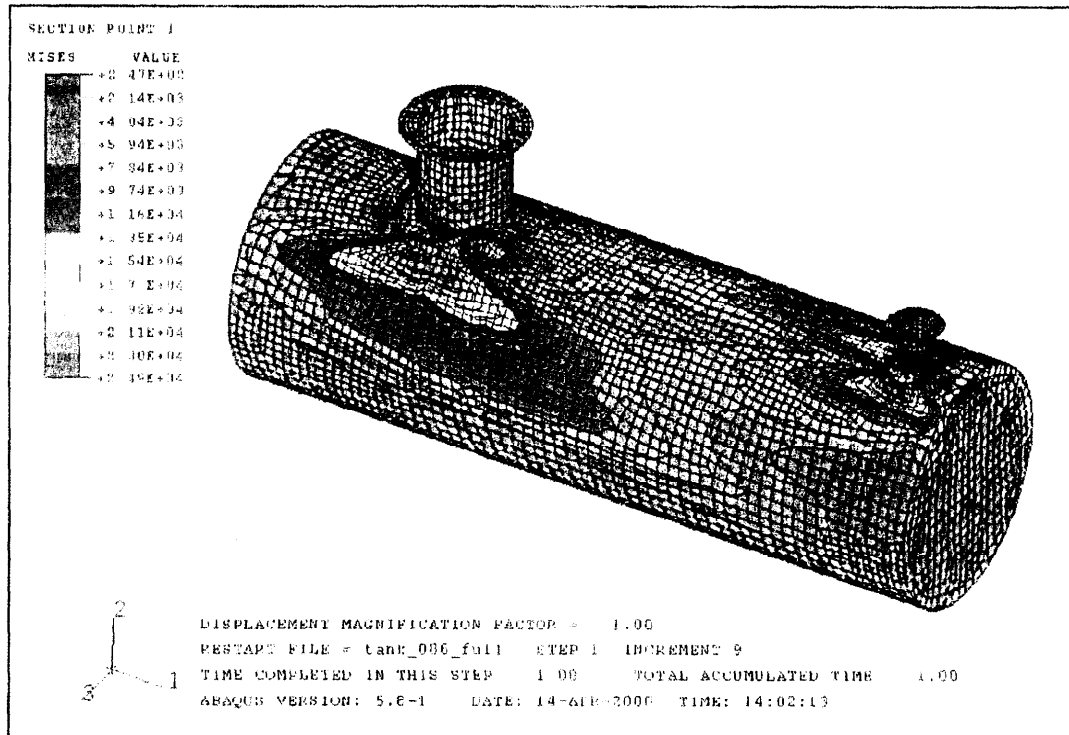
Figure 4 - Von Mises stresses in the tank. Areas in red have reached the yield strength of the 304L stainless steel.

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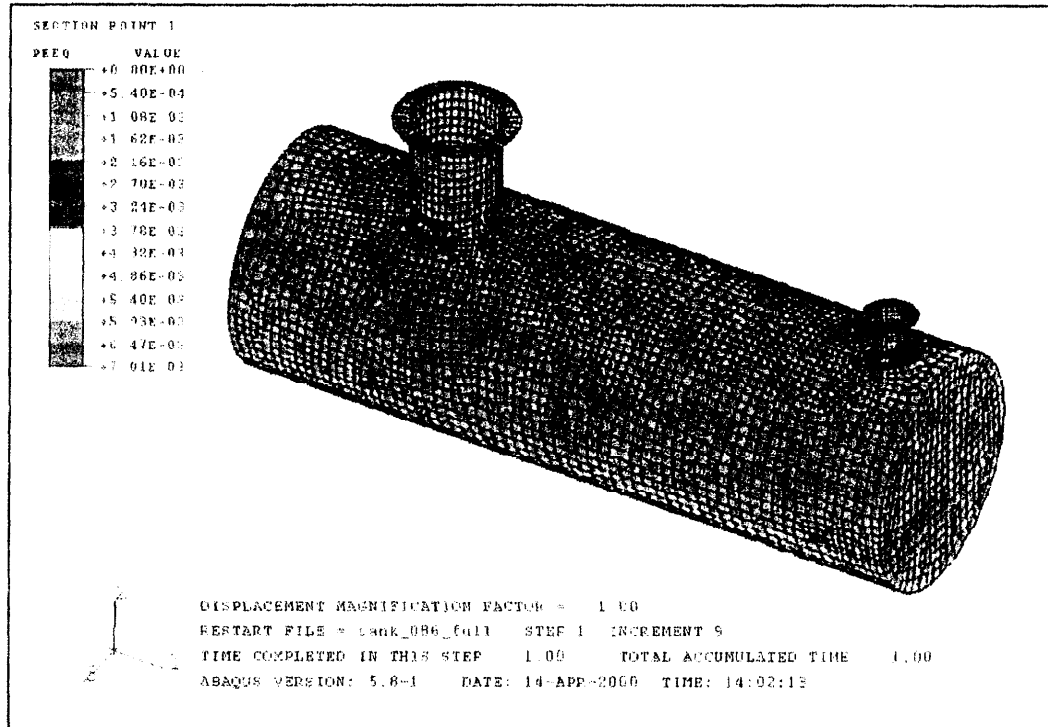**Originator:** B. D. Hawkes   **Date:** 04/17/00   **Checked By:** E. D. Uldrich   **Date:** 04/17/00

Figure 5 - True plastic strains in the tank. Note that the maximum plastic strains do not exceed 1%.

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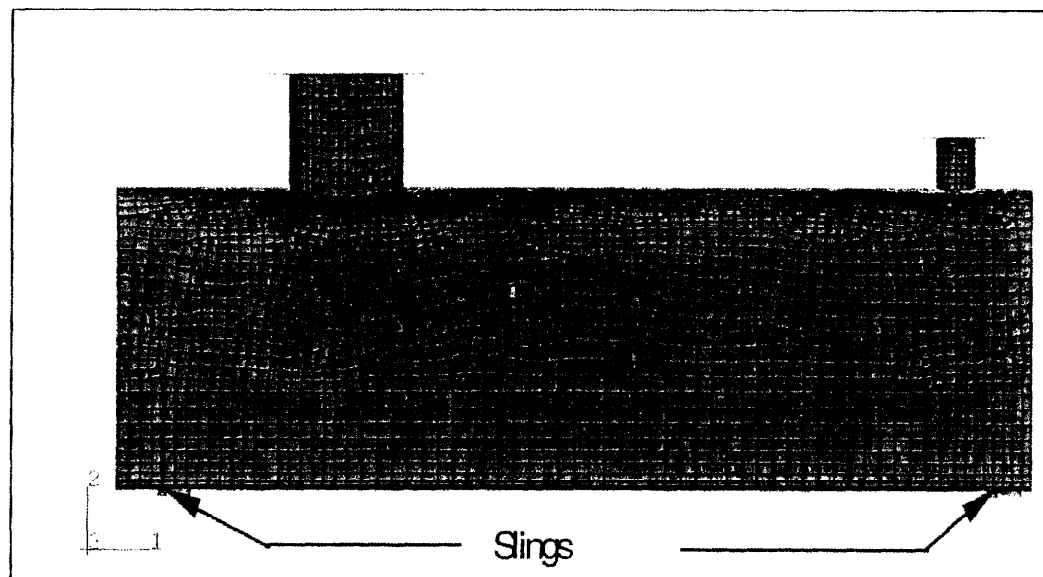

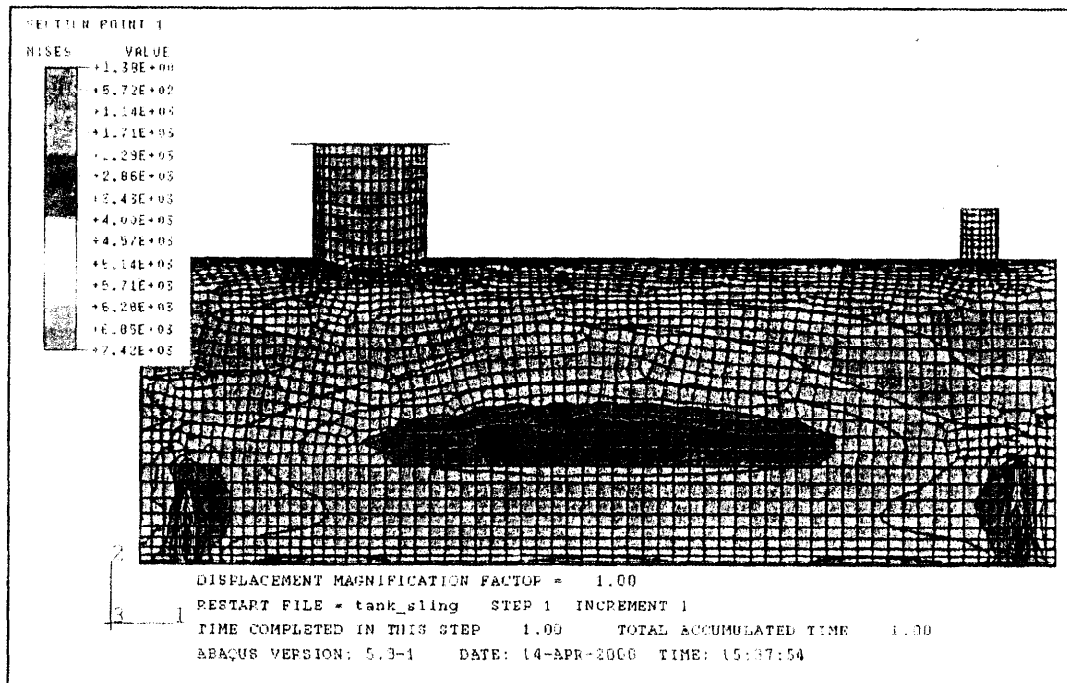Figure 6 - ABAQUS model of tank lifted by slings.

Figure 7 - Von Mises stresses in the tank supported by slings.

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Conclusions

Results of these analyses show that the tank would be safe to lift by the nozzle flanges. Localized plastic deformation occurs in the tank wall where the stresses reach the yield strength of the material, but the plastic strains are small (less than 1%) compared to a rupture strain of about 40%.

Lifting the tank by straps under each end will result in maximum stresses of less than 8 ksi.

Either method of lifting the tank would not cause strains or stresses of sufficient magnitude to rupture the tank.

Recommendations

The assumptions made in this report concerning the condition of the tank should be verified before the lift to assure that they represent the actual conditions of the tank.

References

1. ASME Boiler and Pressure Vessel Code, Section II, Part D, Materials – Properties, 1998 Edition

2. Ryerson Data Book, Joseph T. Ryerson & Co., page 33, 1967

3. I-DEAS Version MS7, Structural Dynamics Research Corp., Milford, Ohio, 1999

4. ABAQUS Version 5.8, Hibbitt, Karlsson & Sorensen, Inc., Pawtucket, RI, 1999